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INDUSTRIAL WASTES ALONG THE NIAGARA FRONTIER AND THEIR EFFECT ON THE INTERNATIONAL BOUNDARY WATERS

Hayse H. Black, et al

Environmental Health Center
Cincinnati, Ohio

1954

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INDUSTRIAL WASTES ALONG THE NIAGARA FRONTIER AND THEIR EFFECT ON THE INTERNATIONAL BOUNDARY WATERS*

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INDUSTRIAL WASTES ALONG THE NIAGARA FRONTIER AND THEIR EFFECT ON THE INTERNATIONAL BOUNDARY WATERS

The "Niagara Frontier" dates back to 1764 when Sir William Johnson, serving the English Crown, acquired from the Seneca Indians a strip of land four miles wide on each bank of the Niagara River. This area has continued through the years as a truly American Frontier. Since the advent of hydro-electric power from Niagara River in 1895, industry has played an ever increasing role in the development of this area. Today Buffalo, the Tonawandas, and Niagara Falls, New York constitute one of the highly industrialized areas of the Nation. This discussion is confined to those industries located in the state of New York with particular reference to the International Boundary Waters during the past five years. The East End of Lake Erie is included because of tributaries and Buffalo Outer Harbor, all of which have bearing on Niagara River pollution. Likewise the effect of lower Niagara River pollution is traced into Lake Ontario (Figure 1).

BOUNDARY WATERS CONTROL

Use of these International Boundary Waters is controlled by an International Joint Commission, consisting of six members, established in 1909 by a treaty between Great Britain and the United States. Article IV of this treaty stipulates that boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other side. At the request of the two Governments, the International Joint Commission conducted a comprehensive survey of these Boundary Waters and principal pollution sources in 1948 and 1949. This work in the United States was performed by the Public Health Service under the general direction of a Board of Technical Advisors composed of eight

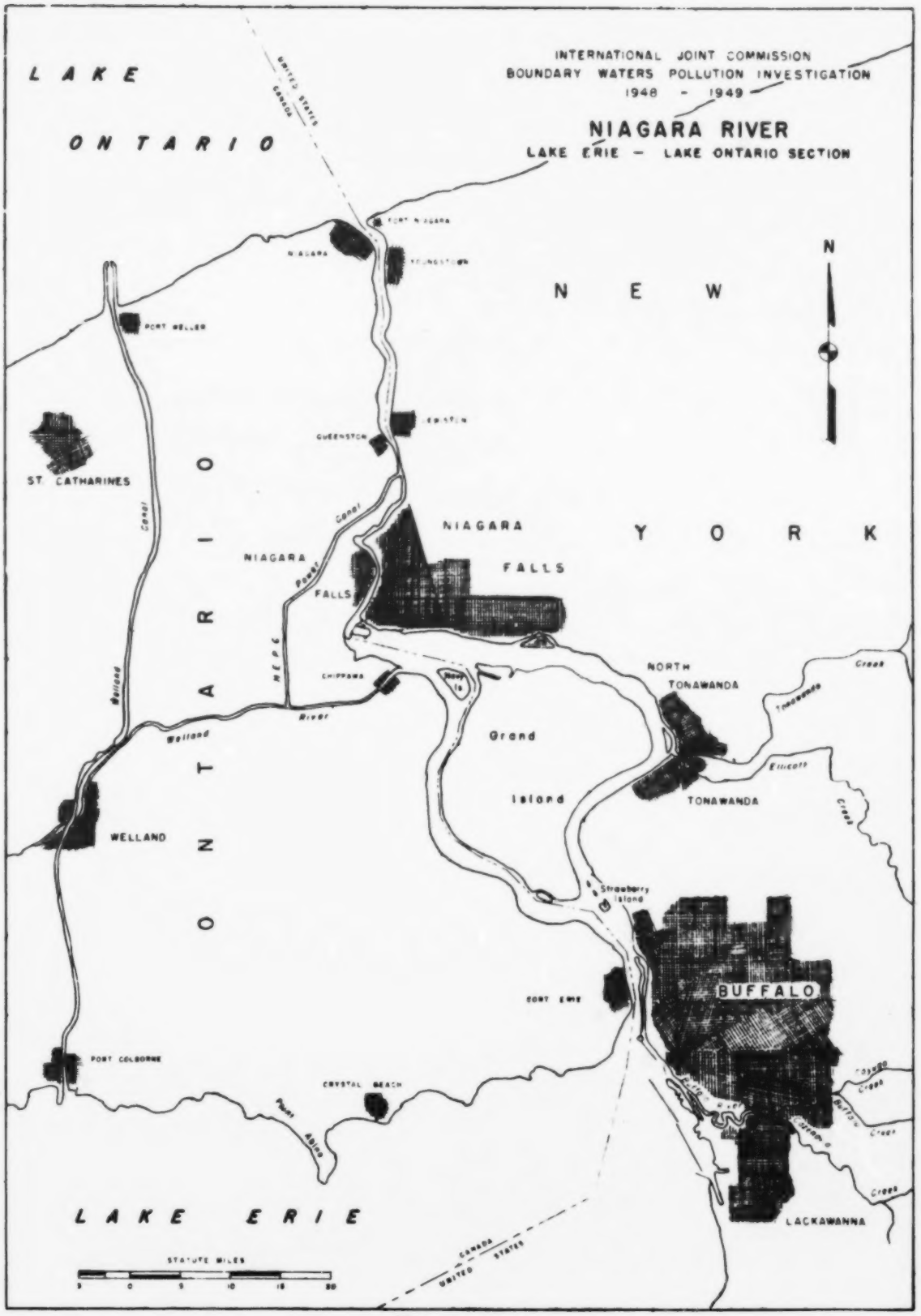

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
NIAGARA RIVER
LAKE ERIE - LAKE ONTARIO SECTION
LAKE
ONTARIO
UNITED STATES
CANADA
N
N E W
Y O R K
PORT WELLER
ST. CATHARINES
QUEENSTON
NIAGARA
FALLS
NIAGARA
FALLS
Welland Canal
Welland River
CHIPPAWA
Grand
Island
NORTH
TONAWANDA
TONAWANDA
WELLAND
Strawberry Island
BUFFALO
PORT COLBORNE
CRYSTAL BEACH
LAKE ERIE
LACKAWANNA
STATUTE MILES
5 0 5 10 15 20

FIGURE 1

engineers, four from the United States and four from Canada. The report on these studies, dated 1951, was accepted by both Governments (1).

An outgrowth of the 1948-1949 studies was the adoption by the International Joint Commission of "Objectives for Boundary Waters Quality Control." Early in 1952, the Commission appointed an Advisory Board on Control of Pollution of Boundary Waters. This Advisory Board like the Board it succeeded, is made up of eight Engineers representing the two Governments, the State of New York, and the Province of Ontario. One function of the Advisory Board is to critically examine industrial waste problems and pollution abatement programs directed toward compliance with the Objectives and to evaluate and interpret progress for the International Joint Commission. The Advisory Board reports semi-annually to the Commission.

Hydrographic Information

Niagara River is unique in many respects. It serves as a connecting link, a spillway, from Lake Erie to Lake Ontario. In a total length of some 37 miles, by way of the east channel, the water level drops 326 feet with half of this occurring midway at the falls. The upper river is divided by Grand Island, a 27 square mile tract of land. Flow distribution has been determined as 43% through the east channel and 57% through the west channel. River distances around Grand Island are 13 miles for the east channel and 9 miles for the west channel.

Transition from Lake Erie to Niagara River is through a funnel shaped section which narrows in a distance of about 1 1/2 miles to a constricted channel in rock with a minimum width of 1500 feet and an average depth of about 17 feet where current velocities as great as 10 miles per hour (15 f.p.s.)

occur. Navigation past these rapids is made possible by the Black Rock Canal which parallels the river for 3 1/2 miles on the United States side. Water levels in this canal are controlled by locks at the northern end of Squaw Island.

The constricted channel continues for approximately 2 miles and then gradually widens to 5900 feet at the head of Strawberry Island. According to the United States Lake Survey, the mean velocities at the head of Strawberry Island are 2.80 feet per second in the United States Channel and 2.60 feet per second in the Canadian Channel. The swiftest velocities in the river occur in the Whirlpool Rapids below the falls where velocities as high as 30 miles per hour (45 f.p.s.) have been estimated. The full diluting power of the river is probably first realized in this stretch.

The East or Tonawanda Channel commences at Strawberry Island, immediately upstream from the southern tip of Grand Island. A dredged channel 21 feet deep lies east of Strawberry Island from Black Rock Canal to a point opposite Motor Island. From Motor Island to Tonawanda Island there is a natural average depth of 20 to 28 feet. The balance of the East Channel is comparatively shallow, with widths varying from 1600 to 4000 feet. A channel 12 feet deep for vessel navigation is maintained through the downstream 8 1/2 miles of the East Channel to Niagara Falls, New York.

The International Boundary follows the West or Chippewa Channel. This channel, used only by small craft, varies in width from 2000 to 4000 feet, and has depths from 15 to 30 feet. The West Channel divides at Navy Island and then recombines with the East Channel to form the large body of water upstream from the rapids above Horseshoe and American Falls.

The total catchment area above Niagara Falls is 265,095 square miles. By

way of comparison, this is exactly one half the size of the Missouri River drainage basin. The average flow of Niagara River at its inlet from Lake Erie for the 90 year period (1860-1949) was 202,000 cubic feet per second (c.f.s.). The mean monthly flow figures range from 117,000 to 253,000 c.f.s. Cycles of precipitation and other meteorological factors cause a range in the annual mean discharge rate for the river of approximately 75,000 c.f.s.

The rate of flow in Niagara River is dependent almost entirely upon the water level of Lake Erie at Buffalo. Lake Erie is the most tempestuous of the Great Lakes due to its position in relation to storm tracks and its shallow depth (mean depth of 90 feet). Storms associated with local variations in atmospheric pressure create seiches which cause the lake level to fluctuate widely. A continuing east wind drops the lake level below the Low Water Datum (L.W.D.)* making it impossible, at times, for ships to enter Buffalo Harbor. On one occasion, the rock bottom at Fort Erie was reported exposed. Similarly, a continuing strong southwest wind has raised the level in the harbor as much as eleven feet above Low Water Datum. These major variations in lake level at Buffalo augment pollution of the Boundary Waters through purging of tributary streams.

Boundary Water Tributaries

Most of the industries in this area, requiring large volumes of water for cooling and process, are so located that water can be pumped from and returned directly to the Boundary Waters. The concentration of industries located along Buffalo River is the one exception. Tonawanda Creek, Buffalo River, and Ellicott Creek represent 87.5% of the area in the United States draining directly to Niagara River. Ellicott Creek is actually a tributary of Tonawanda Creek although their confluence is less than a half mile from Niagara River. Some of the smaller tributaries likewise drain industrial areas and discharge significant wastes. The principal tributaries and their respective drainage areas are listed below.

* Low Water Datum is the level below which the lake should seldom go. It was established in 1934 for Lake Erie as 570.5 at Cleveland

TABLE I

Stream	Drainage Areas in Square Miles Tributary to Niagara River	Drainage Areas in Square Miles Tributary to Lake Erie-East End
Buffalo River	424	
Scajaquada Creek	22	
Tonawanda Creek (Barge Canal)	530	
Ellicott Creek	119	
Cayuga Creek	34	
Miscellaneous		
Upper River	77	
Lower River	19	
Smokes Creek		33
Eighteenmile Creek		110
Rush Creek		11
Total	1225	154

Buffalo River is one of the most significant tributaries from the standpoint of Boundary Water pollution. This stream is a dredged basin of some 165,000,000 cubic feet extending from Buffalo Harbor to the confluence of Buffalo and Cazenovia Creeks, a distance of approximately 6 miles. Extremely low flows during the summer months make this stream virtually a pool. The lowest average monthly flow during the eight year period 1943-1950 inclusive occurred in August 1949 when the average discharge was 47.4 c.f.s. which in-

cluded 10 m.g.d. Buffalo City water used by the industries. The minimum daily flows in Buffalo River are of even greater significance. The yearly low, daily discharge rates, exclusive of city water used and discharged by the industries, for three recent years were:

Date	Rate cfs
August 24, 1941	9.2
September 18, 1948	10.3
August 27, 1949	12.3

Flood flow has been estimated as high as 27,000 c.f.s. Flash runoff and lake seiches, following an extended drought, have a definite purging effect on Buffalo River.

Tonawanda Creek serves as the New York State Barge Canal between Niagara River and the hamlet of Pendleton, a distance of 12 miles. During the navigation season, April 1 to December 1, canal operations require 1000 c.f.s. which normally exceeds the flow in Tonawanda Creek. This requirement causes reversal of flow in the lower reaches of the creek which results in flow of Niagara River water to Tonawanda Creek. Somewhat less water passes through the canal when it is closed to navigation. Total flow from Tonawanda Creek to Niagara River occurs during a one month period each year when the canal is dewatered for inspection and repairs.

Buffalo River Pollution Abatement and Industrial Water Supply Project

During the period May to October, 1946, the Buffalo Sewer Authority, in cooperation with industry, made a comprehensive survey of Buffalo River and simultaneously examined the effluents from the five major industries contributing wastes to the stream. This survey resulted in a pollution abatement

program, one phase of which was a proposal now known as "Buffalo River Pollution Abatement and Industrial Water Supply Project." (2).

The original plan contemplated a water system which would provide the 5 major Buffalo River industries with clean, cool, alkaline water direct from Lake Erie for process and cooling purposes. A system having an ultimate capacity of 180 m.g.d. was proposed. The proposed project had the further objective of creating sufficient flow in Buffalo River, during periods of dry weather flow, to prevent concentration of waste in the stream thus eliminating the threat of "slugs" of waste reaching Niagara River.

With the objective of expediting this project, an exploratory conference was sponsored September 19, 1952, at Buffalo by the New York State Joint Legislative Committee on Natural Resources and Interstate Cooperation. Representatives of the city of Buffalo, the five major industries located along Buffalo River, the New York Water Pollution Control Board, the New York State Department of Health, and other interested agencies participated in this meeting. It was agreed at this conference that an engineering study should be made of this proposed water supply development.

The Engineer's preliminary plans for this project have been completed and a meeting of representatives of the five industries with the Buffalo Sewer Authority has been arranged with a view toward determining the ways and means and under what terms this project can be undertaken. Members of the Joint Legislative Committee have expressed their desire to assist in any way possible and their willingness to sponsor any legislation that may be found necessary.

Uses of Boundary Waters

Knowledge of this area leads to the unequivocal conclusion that these Boundary Waters must have many and varied uses. The New York Water Pollution

Control Law is predicated on this reality and through classification, the Water Pollution Control Board endeavors to establish best usage of waters in the public interest. Bases for recommended classification and assignment of standards of quality and purity for waters on the U. S. side of the International Boundary are contained in a Board report dated May 1953. (3).

Pursuant to provisions of the Water Pollution Control Law, public hearings were held in Buffalo, N. Y., October 21, 1953 to consider proposals for the official classification of the Boundary Waters and tributaries thereto. Testimony submitted at these meetings and briefs filed prior to March 1, 1954, together with the comprehensive Board report previously mentioned, will serve as bases for classifications to be established by the Water Pollution Control Board.

Review of all data pertaining to the East Channel of the Niagara River, by the New York State Department of Health, revealed that no one of the seven adopted classes applied. (4). Accordingly, a special class (Niagara River) has been proposed. The standards specified for this Special Class were intended to be consistent with the water quality objectives of the International Joint Commission. (5). The next step in this program is formal classification of Niagara River and its tributaries by the New York State Water Pollution Control Board.

Regardless of what classification may be established, the present water requirements and water uses must continue to be satisfied. Domestic water supply receives first priority on Boundary Waters use. Approximately 935,000 persons on the U. S. side are presently supplied by municipal plants taking water from the east end of Lake Erie and Niagara River. In addition, the Falls attract some three million visitors annually. High quality water requirements for certain industrial processes likewise establish a high priority

for industrial water supplies.

An abundance of fresh water for process, low cost hydro-electric power, and lake transportation have been major factors in the industrial development and prosperous growth of this area. Public acceptance of the development of natural resources was further exemplified by the treaty of 1950 which virtually doubled the volume of water which can now be diverted from the Falls for power. It would seem prudent to qualify the expression "Public acceptance." Although the treaty stipulates minimum discharge rates over Niagara Falls, to some observers this may create an aspect of artificiality and utilitarian desecration of one of the most magnificent and impressive terrestrial natural objects. To others, full development of this recently authorized power potential will be another triumph for the Engineer.

Concurrent with water supply, navigation, and power uses specifically mentioned in the treaty of 1909, these Boundary Waters must continue to receive treated domestic sewage and residual wastes from industry. This is recognized as an essential and legitimate water use. Likewise, fish and wildlife must be protected and the intangible recreational values must be preserved. These demands apply equally on either side of the International Boundary.

Principal Pollution Sources

Significant pollutional materials discharged to the Boundary Waters include: Untreated and partially treated domestic sewage, industrial wastes, intermittent release of sewage from both freight and passenger vessels, and the leaching from dredge dumps. To these must be added combined sewer overflows and the irregular discharge from tributaries and Buffalo Harbor. Location of industrial sewer outfalls for the major industries and the points of discharge from the larger municipal sewerage systems are shown on Figure 2.

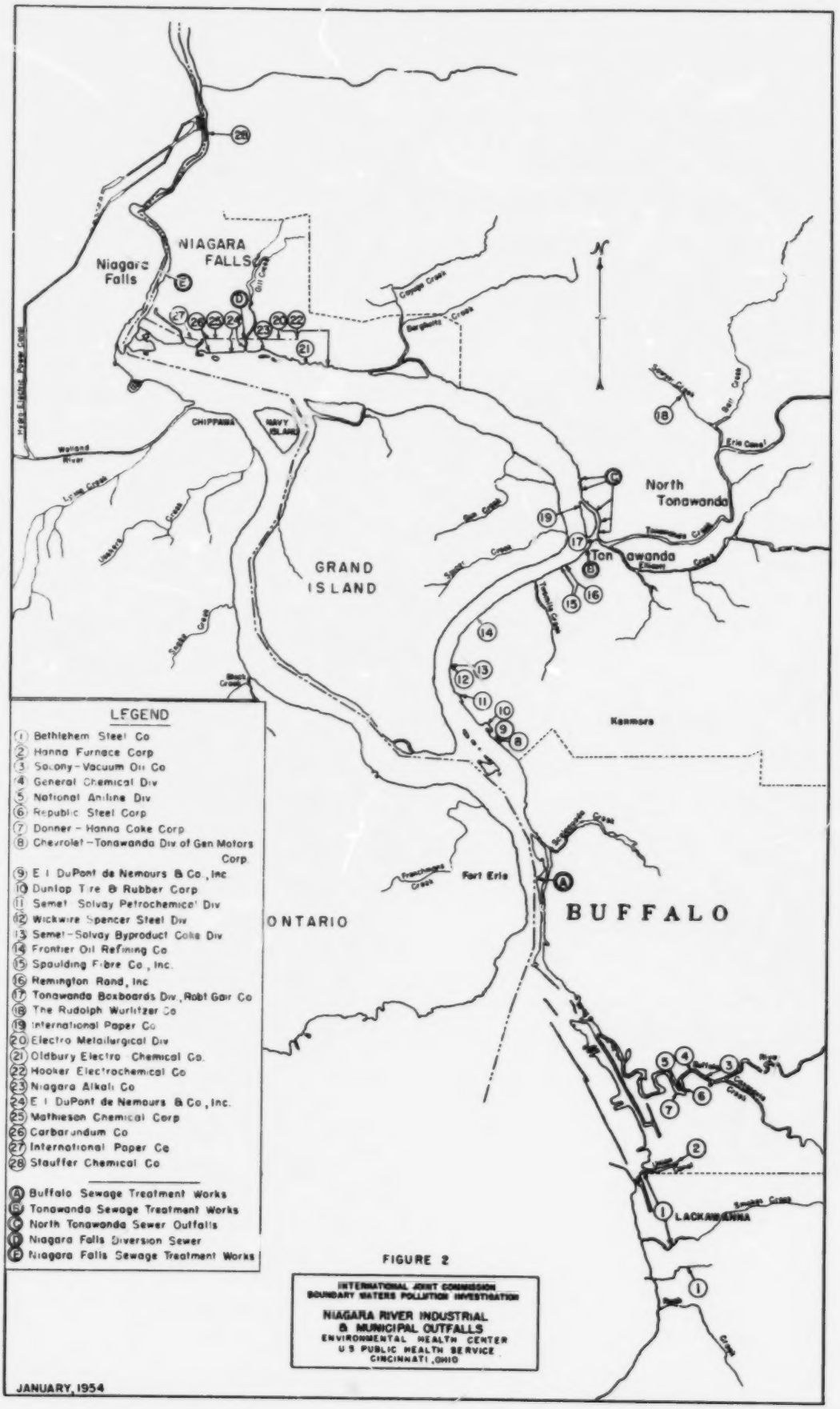


FIGURE 2

INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION

NIAGARA RIVER INDUSTRIAL & MUNICIPAL OUTFALLS

ENVIRONMENTAL HEALTH CENTER
U S PUBLIC HEALTH SERVICE
CINCINNATI, OHIO

JANUARY, 1954

Domestic Wastes

Discharge from municipal sewer systems has a place in this discussion because of the industrial wastes they receive. This is particularly true for the Niagara Falls and Buffalo sewage treatment works. Most of the sewers in the area are combined, receiving both storm water and sanitary sewage. There are numerous sewer overflows to tributaries and to Niagara River directly. During periods of excessive runoff, the flushing of sewers and overflows introduce a significant additional pollution load on the stream.

Based on the 1950 census, there are 1,038,000 people residing in the area draining to Niagara River and to the East End of Lake Erie. Of this total, 90 per cent are served by public sewer systems. Some degree of treatment has been provided for 97 per cent of the sewage from the sewered areas but only 10 per cent receives complete treatment. The domestic sewage problem is beyond the scope of this paper but details are given in the Water Pollution Control Board Report (3).

Wastes from Vessels

Both passenger and freight vessels navigate the east end of Lake Erie and a considerable tonnage of freight is handled by the New York State Barge Canal. Passenger vessels operating into Buffalo are equipped with sewage holding tanks but these are not presently provided on freighters. Sewage stored in the tanks is usually dumped shortly after departure from the harbor area.

Bilge and ballast water are frequently discharged from vessels. Bilge water includes seepage through the hull, and leakage from water lines, pumps, and machinery and may contain some lubricating oils and greases. Ballast water is used to stabilize the vessel under various operating conditions and is taken on whenever and wherever needed. This requirement frequently transfers water from a polluted zone to a relatively clean area. The waste problem of vessels

is complicated by the fact that they are usually on the move.

Dredge Dump Areas

The U. S. Army, Corps of Engineers, has established and uses two areas in these boundary waters for the dumping of dredged materials. These materials are a combination of rock, silt, sewage solids, and settleable solids from industrial wastes.

Dredged materials from Buffalo River, the entrance to Buffalo River, the Outer Harbor, and Black Rock Canal are deposited in an area at the east end of Lake Erie adjacent to Bethlehem Steel Company property. The south edge of this area is a line perpendicular to shore, at a point a few feet north of the mouth of Smokes Creek, and extending into the lake a distance of 3/4 mile. The west edge of this dump area is in line with the South Pier light at the south entrance to Buffalo Outer Harbor and extends for a distance of one mile. The total area approximates 3/4 of a square mile. Minimum water depth over the dumping ground is 6 feet. The south section of this dumping ground has been used for rock. In the past three years, material was taken to the rock dump for only a short period; all the rest of the time the earth dump was used. It has been reported that this dumping area will be abandoned in 3 to 4 years.

The second dumping ground is located in Niagara River along the north shore of Grand Island and a tip of Buckhorn Island. This dump area is slightly over 1/2 mile east and west and averages about 1/4 mile wide. Material dredged from Niagara River downstream from Tonawanda Island has been dumped in this area in the past. There has been no regular dredging of this channel for many years and only occasional removal of obstacles.

Location of the Lake Erie dredge dump ground is significant because of

its proximity to Erie County Water Authority water intake. (This water purification plant was formerly owned and operated by Western New York Water Company). This intake line extends into the lake a distance of 4425 feet and parallels the south edge of the dump area at a distance of 7/8 mile. Furthermore, this dredge dump creates what amounts to a shallow bay at the outlet of Smokes Creek and serves as a barrier to natural flow along the lake shore in the direction of Niagara River.

Industrial Wastes

There are 32 major industries located along the Niagara Frontier known to have significant liquid wastes. Since these wastes will be discussed in some detail in a subsequent section, only the general location of the industries will be indicated.

There is a concentration of electrochemical, electrometallurgical, carborundum, and allied industries in the city of Niagara Falls. In addition there are specialty paper mills and manufacture of synthetic organic chemicals.

The following types of industries are located in the Tonawandas: plastics, phenolic products, electroplating, textile, pulp and paper, petroleum refining, by-product coke, steel, oil gas, petrochemical, automobile tires, synthetic fiber, and automobile engines.

Buffalo has 5 large industries located along Buffalo River. These include a steel mill with two blast furnaces, by-product coke plant, petroleum refinery, acid plant, and one of the country's largest manufacturers of dyes, dye intermediates, and synthetic organic chemicals.

Along the east shore of Lake Erie in Lackawanna is one of the world's largest integrated steel mills. This includes by-product coke, blast furnaces, and rolling mills in a single plant. There are four additional blast furnaces

in Lackawanna operated by another company.

Industrial Waste Studies

Each of the 32 industries previously mentioned has been visited from one to three times during the past five years. Arrangements for these meetings were made in each case by the New York State Department of Health. Representatives of the State Health Department and the Public Health Service participated in each conference. The Erie County Health Department and the city of Niagara Falls were represented at conferences with industries located in those respective areas.

Engineering Investigations

The initial meeting with each industry was exploratory. The primary objectives were to learn about plant operations and to discuss process and sanitary wastes as they related to pollution of the International Boundary Waters. Major waste sources were inspected along with by-product recovery units and waste treatment systems. Some effluent data were available at the time of the first conferences, but in most cases subsequent studies were necessary.

Industrial Waste Surveys

During and since the 1948-1949 I. J. C. field studies, industries discharging wastes either directly or indirectly to the Boundary Waters have accumulated a considerable amount of information and data pertaining to their respective wastes. The New York State Department of Health and the Public Health Service have participated in much of this work. This participation has ranged from consultation relative to sampling procedures and analytical methods to comprehensive cooperative industrial waste surveys.

The Public Health Service conducted seven investigational research projects during and immediately following the I. J. C. field program. These were cooperative projects with industry arranged by the State Department of Health. State Engineers conducted a similar study at one of the large electrochemical plants. Several of the industries proceeded independently with comprehensive surveys and submitted complete reports on their findings to the New York State Department of Health and the Public Health Service.

Control and Treatment

These industries have, for the most part, elected to solve their waste problems independently through process control and separate waste treatment systems. The character and volume of wastes have dictated this approach in several cases and in others municipal sewers have not been accessible. Profitable by-product recovery has solved several waste problems.

Determination of the efficacy of industrial waste control and treatment is a continuing program. One industry maintains an accurate record of effluent quality on an 8 hour shift basis. Another industry effectively employs ultra violet absorption techniques in effluent control. The potential economies in positive industrial effluent control and the value of such records are becoming more and more evident.

Combined Treatment

The Buffalo Sewer Authority provides treatment for a variety of industrial wastes. Treatment consists of prechlorination, sedimentation and separate sludge digestion, and incineration of the dewatered sludge. Industries served include: rubber reclaiming, tanneries, meat packing, synthetic organic chemicals, and others. A special charge is made for trade wastes having chlorine demand and suspended solids significantly higher than the normal

Buffalo domestic sewage. This surcharge is computed by a formula derived for the purpose (5). Digestion capacity of this plant is currently being increased 125 per cent and an elutriation unit is being installed.

The Niagara Falls Sewage Treatment Works receives large volumes of clean cooling water and substantial amounts of process wastes from the local industries. At one time, it was reported that 85 per cent of the flow was of industrial origin (6). Although a diversion sewer was constructed by the city to receive cooling water and innocuous or treated trade wastes, it has actually had limited use. In the past, trouble has been caused by obnoxious gases released from trade wastes discharged to the diversion sewer. For some of the industries, use of the diversion sewer or return of cooling water to the river requires pumping whereas the city system permits gravity flow. The most serious operation problems at the treatment plant, caused by these industrial wastes, have been clogging of screens, obnoxious and dangerous gases, and erratic chlorine demand. Normally sewage entering the plant contains free chlorine, occasionally as much as 300 ppm. Conversely, at times, the influent has had a chlorine demand of 100 to 200 ppm. Through cooperation of all concerned, these conditions have been much improved.

Pollutional Constituents Studied

The program was designed to correlate recognized objectionable wastes with their effects on the receiving waters. Analytical determinations were selected with the hope of tracing the course of pollutional materials and of determining their persistence in those natural waters. This work was complicated by the limitations of analytical procedures for determination of specific constituents in extremely high dilutions. Industrial effluents were examined for suspected toxic materials even though these were not normally

detectable in the stream.

Review of the analytical data contained in the I.J.C. 1951 report indicates phenol and coliform to be the most significant determinations. These constituted positive parameters of pollution in that each had direct bearing on public water supplies and both persisted into Lake Ontario.

Tests for chlorine demand, odor, and iron were an aid in evaluating pollution and its effect on treatment of water for domestic use. Cyanide concentration was determined for industrial effluents containing cyanogen compounds because of their threat to aquatic life. Examination for oils was of special value in study of wastes from petroleum refineries, steel mills, and other large users of oil products. Determinations for suspended solids, acidity, and alkalinity were significant even though the effect of these pollutants was usually localized in the vicinity of the contributing outfalls. The results for B.O.D. and ammonium compounds were a further aid in appraisal of pollution.

Quantities of industrial wastes determined as a part of the 1948-1949 I. J. C. Studies are recorded in Table 2. Similar data, based on recent reports from industry, are tabulated for comparison in Table 3. Intermittent discharge of phenol has been reduced to daily basis in order to give a true picture of the total amount entering the river. This conceals the peak rates of discharge for the phenol bearing wastes. The cyanide data do not include electroplating wastes inasmuch as these plants were not surveyed in 1949.

TABLE II

SUMMARY OF INDUSTRIAL WASTES DISCHARGED DAILY IN 1949

AREA	Gibbs Phenol (lb.)	Cyanides CN (lb.)	Ammonium Compounds NH_3 (lb.)	Oils (U.S. gal.)	Suspended Solids (tons)	Acid Equiv. $CaCO_3$ (tons)
Lake Erie	155	175	1,750	990	130	37
Niagara River	5,045	1,545	1,165	1,530	305	55
TOTAL	5,200	1,720	2,915	2,520	435	92

TABLE III

SUMMARY OF INDUSTRIAL WASTES DISCHARGED DAILY IN 1953

AREA	Gibbs Phenol (lb.)	Cyanides CN (lb.)	Ammonium Compounds NH_3 (lb.)	Oils (U.S. gal.)	Suspended Solids (tons)	Acid Equiv. $CaCO_3$ (tons)
Lake Erie	100	175	590	990	60	37
Niagara River	4,185	560	1,450	1,720	205	23
TOTAL	4,285	735	2,040	2,710	265	60

Phenolic Type Materials

The primary sources of phenolic type materials in this area are by-product coke plants, manufacture of phenolic resins, and the catalytic cracking of petroleum. Secondary sources include oil-gas generators and sewage treatment plants receiving trade wastes; effluents from both the Buffalo and Niagara Falls plants contained phenol in 1949. One significant phenol discharge to Buffalo River has recently been eliminated by substitution of a new process. Because of the offensive character of phenol in extremely high dilutions, traces of phenol have been reported.

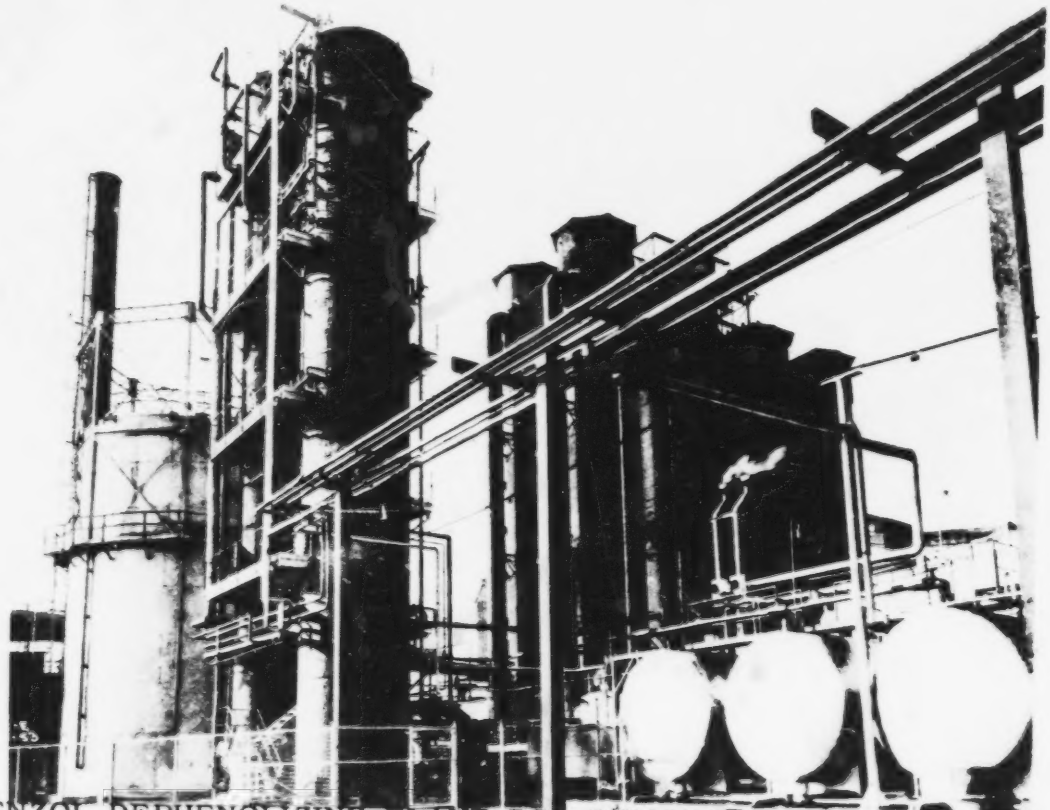
A. By-Product Coke

Three by-product coke plants in the Lackawanna-Buffalo-Tonawanda area have a combined capacity for carbonizing 17,100 tons coal per day. In December 1953, these coke plants averaged 90% capacity, which was comparable with operation during the 1948-1949 studies. This represented 15,400 tons coal carbonized and production of 10,800 tons of coke daily.

Two of these coke plants operate mostly on blast furnace coke, at relatively high coking temperatures, thus producing a minimum of phenol. The third plant produces both domestic and blast furnace coke. The latter plant recovers ammonia by the indirect process and accordingly makes considerably more phenol per ton of coal carbonized than either of the other two (7).

Bethlehem Steel Company has dephenolized ammoniacal liquor for some 25 years at the Lackawanna Mill. This company installed a benzol extraction phenol recovery system during 1953. The new unit has greater capacity and is more efficient than the dephenolizing system it replaced. The other two by-product coke plants do not presently dephenolize. By-product coke phenol and phenolic equivalents, including the residual from Bethlehem Steel Company, amounted to

A. P. I. MASTER OIL-WATER SEPARATOR - Fig. 5
(Courtesy Frontier Oil Refining Corporation)



BENZOL DEPHENOLIZING PLANT FOR REMOVAL OF PHENOL FROM BY-PRODUCT COKE AMMONIACAL LIQUOR
(Courtesy Bethlehem Steel Company)
Fig. 3

3120 pounds per day or 73 per cent of the total phenol being discharged during 1953 to the International Boundary Waters and tributaries.

B. Plastics

Production of phenol-formaldehyde type resins at two plants located in the Tonawandas results in the second major source of phenol. In the manufacture of these resins, a distillate is produced during the dehydration stage which contains (depending on the resin being produced) 2 to 8 per cent phenol. This is a batch operation and the distillate is collected in storage tanks for gravity separation of resinous material.

One of these plants operates an efficient benzene extraction system for recovery of phenol from this distillate (8). This recovery system is presently operated 5 days per week with an average efficiency of 96 per cent. Improvements are being made which will increase the efficiency of this phenol recovery unit to 99 per cent. This plastics plant also manufactures phenol by the regenerative or catalytic vapor-phase process but there is very little phenol loss from this operation.

The other plastics plant provides long-time storage of the distillate but does not dephenolize. Phenolic waste from this plant is drained once a week over an 18 hour period. When the benzene extraction phenol recovery plant is operating and the second plastics plant is draining settled distillate, the combined phenol discharge rate from these two sources amounts to 2035 pounds per 24 hour day.

C. Petroleum Refining and Oil-Gas

Two petroleum refineries process approximately 50,000 barrels crude per day. These refineries both operate catalytic cracking units which produce somewhat more phenolic materials in the cracked gasoline than thermal cracking. Spent caustic containing high phenol concentrations is excluded from the sewers

BENZENE EXTRACTION SYSTEM FOR RECOVERY OF PHENOL FROM PROCESS WASTES FROM MANUFACTURE OF PHENOL - FORMALDEHYDE TYPE RESINS
(Courtesy Durez Plastics & Chemicals, Inc.)
Fig. XX

at each refinery.

There are four oil-gas generators in the Buffalo-Tonawanda area with a total capacity of 22,000,000 cubic feet of gas per 24 hour day. Three of these generators are standby units being used to supplement natural gas during peak demand. The fourth unit operates continuously supplying oil-gas for a petrochemical plant. Phenolic wastes presently discharged from the two refineries and the oil-gas generator amount to 350 pounds per day.

D. Municipal Sewage Plants

The Buffalo Sewage Treatment Works effluent contained 75 pounds phenol and the Niagara Falls Treatment Plant effluent 275 pounds phenol per day at the time of the I. J. C. field studies in 1949. The significance of this phenol is the fact that it represents chlorophenol compounds. Chlorine is applied at both treatment plants for disinfection. It is not uncommon for the Niagara Falls sewage to contain residual chlorine as it reaches the plant.

Cyanide

Cyanide was present in varying concentrations in the wastes from the following types of plants: by-product coke, electrometallurgical, electrochemical, blast furnaces, and electroplating. Analytical work was confined to the cyanide radical and reported as CN.

A. By-Product Coke

The principal cyanogen compound in coal gas is hydrogen cyanide (HCN). Hydrocyanic acid is an extremely water soluble compound and may be expected in water condensed from the gas or water that has been in contact with the gas.

The most potent source of hydrogen cyanide in coke plant wastes is the gas final cooler water. It is common practice to reuse this cooling water by means

of closed systems and cooling towers. When the cooling tower is in operation, this source of cyanide is eliminated except for possible leaks, overflow, or draining of the system. The two coke plants employing semi-direct ammonia recovery have closed systems for the gas final cooler water.

The indirect ammonia recovery system, used by the third coke plant, provides adequate cooling of the gas in the counterflow ammonia scrubbers thereby obviating the need for final coolers ahead of the light-oil scrubbers. However, the ammoniacal liquor from the indirect system absorbs more HCN from the gas than it does in the semi-direct process because of the lower temperature and greater volume. Some of this cyanide carries through into the ammonia still waste. This coke plant produced 0.038 lb. cyanide (CN) per ton of coal carbonized as compared to 0.007 lb. for one of the other plants employing semi-direct ammonia recovery.

Total cyanide discharged from these three coke plants in 1949 averaged 215 pounds daily. Concentrations in the effluents varied between 0.6 and 1.5 ppm CN. Most of this cyanide originated in the ammonia still waste and condensates at the benzol departments.

B. Electrometallurgical

The largest single source of cyanide in the area was the carbide and ferro-alloy furnaces gas scrubber water at Niagara Falls. This scrubber water contained HCN concentrations as high as 20 to 30 ppm. This amounted to 720 pounds cyanide (CN) daily. Alkaline chlorination is being used to reduce this cyanide to nitrogen and carbon dioxide.

C. Electrochemicals

The 1949 studies indicated 400 pounds cyanide (CN) in the wastes from an

electrochemical plant located in Niagara Falls. This plant manufactures a large number of end products among which are metallic cyanides and sulfocyanides.

Production of sodium cyanide requires water for scrubbing gas emanating from the reaction vessels and for cooling the casting machine molds. In these operations, water comes in contact with traces of the product. Although a portion of the sodium cyanide production has been transferred to another plant, this process still contributes some cyanide waste.

Metallic cyanides and sulfocyanides are manufactured by standard aqueous processes consisting essentially of double decompositions and addition reactions. Water is used in these processes for dissolving raw materials, washing during filtering operations, and scrubbing vapors coming off the reaction vessels. Process modification and more accurate control have substantially reduced the cyanide concentration of these wastes. Based on improvements reported, it was estimated that cyanide losses from this plant during 1953 did not exceed 150 pounds CN daily.

D. Blast Furnaces

Blast furnace flue gas wash water contains relatively low concentrations of HCN as compared with carbide and ferro-alloy electric furnaces. Data from two studies indicate a range of 0.16 to 2.2 ppm HCN. Furthermore, blast furnaces use much less water in the wet scrubbers per 1000 feet of gas than the electric furnaces. Considering capacity production of pig iron for the area, this source would give 275 pounds cyanide (CN) daily.

E. Electroplating

Several industries in this area operate metal-finishing departments. Two

of the larger plants were visited to observe waste control procedures but no studies were made. These plants used sodium, copper, and zinc cyanides in conventional plating operations. Both automatic and semi-automatic electroplating machines were in service.

Consideration had been given to reduction in dragout and to minimizing loss of useable plating materials. Sludge accumulating in plating tanks was reported removed routinely and disposed of at the city dump. Plating chemicals were replenished when necessary and the solutions were being used indefinitely. Rinse waters were the only waste discharge reported from the plating departments visited. Cognizance had been taken by plant officials and operators of the highly toxic character of plating solutions. Information obtained indicated these metal-finishing establishments to be minor sources of cyanide.

Ammonium Compounds

Significant industrial sources of ammonia were the by-product coke plants and plastics manufacture. However, these were relatively minor as compared with the ammonia in the treated domestic sewage. At the time of the I.J.C. field studies in 1949, the Buffalo and Niagara Falls sewage plant effluents contained more than 5 times as much ammonia as the industrial wastes from the area. Free ammonia and ammonium salts were determined.

The high ammonia losses in the Lake Erie area during 1949 indicated only partial recovery of fixed ammonia from the ammoniacal liquor at the Lackawanna coke plant. Recent study of the effluent from this plant has shown marked reduction in ammonia loss. The wastes from one plastics manufacturing plant surveyed in 1949 contained 380 pounds ammonia (NH_3) daily.

Oils and Greases

Petroleum refineries, steel rolling mills, and a plant producing automo-

bile engines were the principal contributors of oily wastes. There were numerous other sources of lesser importance. Increase shown for oil losses (Tables 2 and 3) was caused primarily by sludge accumulation and reduced retention in one of the refinery master oil-water separators. Oil losses would be considerably higher if it were not for recent improvements. Some of the most significant developments are briefly described.

A. New Oil-Water Separator

One refinery placed a new A.P.I. master oil-water separator in operation during September 1953. This separator is of the latest design incorporating the open-channel approach and a vertical-slot baffle type inlet to give uniform unidirectional flow. The unit has two single-stage chambers in parallel each equipped with flight scrapers and facilities for sludge and oil removal. A company report for separator effluent analysis showed 46 ppm total oil.

B. Water Lubricated Bearings

Progress has been made in steel mills in reducing oil losses by use of water lubricated composition bearings in lieu of oil lubricated bearings. A new blooming mill installed in 1951 was equipped in large part with the water-cooled type bearing. As operations permit, installation of bearings of this type will be continued in the finishing mills. Recently a large number of table roll bearings in these mills have been changed from oil to grease lubrication which further minimizes loss to sewers.

C. Automobile Engine Oil Waste

Oils wasted from the automobile engine factory, amounting to 545 gallons per day, were approximately 2/3 soluble and 1/3 insoluble. Wastes high in insoluble oil were passed through a two compartment, baffled, gravity, oil-water separator which removed as much as 96 per cent of the separable oil.

The insoluble oil in the plant discharge originated in this separator effluent and in larger volumes of waste water throughout the factory. An oil treatment and recovery system is presently under construction which will provide efficient removal of both soluble and insoluble oil from the wastes of this plant.

D. Soluble Oil Recovery

A very effective oil waste treatment system has recently been placed in service at an aviation engine plant in the town of Tonawanda. These wastes include miscellaneous machine oils, soluble cutting oils, and emulsion cleaners which are collected by a separate sewer system. The sequence of treatment is:

1. Removal of insoluble oil from the waste as received is accomplished in two gravity, oil-water separators operating in parallel.

2. Effluent from the separators, which contains approximately 2500 ppm oil, is pumped to a 16,000 gallon influent tank.

3. The soluble oil treatment system is operated at a uniform rate of 50 G.P.M.

4. Alum slurry and sulfuric acid water are added as the waste flows by gravity to a 1000 gallon capacity, mix and flocculation tank. The acid water, from a subsequent skim cooking operation, is used to maintain an optimum pH for coagulation of 4.25.

5. Mixture flows by gravity to a 12,000 gallon settling tank where the floc forms a skim coat on the surface. Effluent from this tank, containing 50 to 150 ppm oil, flows to a 1000 gallon holding tank.

6. Caustic slurry to raise the pH to 5.5 - 6.0 and air at 30 - 35 p.s.i. are introduced as the partially treated waste is pumped from this holding tank to a Colloidair separator. Effluent from the Colloidair system averages less than 30 ppm oil.

7. Material skimmed from the settling tank and from the flotation unit is treated with sulfuric acid in the ratio of 1 per cent by volume. The acidified solution is heated with steam coils to a gentle boil for 30

minutes to cool and to permit separation of the acid water from the oil. Recovered oil goes to waste oil storage and the acid water is used for initial pH adjustment.

Suspended Solids

There was perhaps no pollutional constituent more common to these industries than suspended solids. Out of the 32 industrial plants studied, there were 24, or 75 per cent, that discharged significant quantities of suspended solids. Four industries produced 92.5 per cent of these solids. These were: steel, pulp and paper, electrometallurgical, and electrochemical. The remaining 7.5 per cent originated in a miscalleneous group.

Reports from industry indicate an overall reduction of 39 per cent in suspended solids discharged to the boundary waters and tributaries during the past 5 years. (Tables 2 and 3). The 170 tons reduction does not reveal the increase in suspended solids in liquid wastes brought about by installation of gas, wet scrubbers for air pollution control.

. Steel Industry

Included in this group are blast furnaces, by-product coke plants, and steel rolling mills for the entire area. Iron ore, coke fines, and mill scale are the principal suspended solids in the wastes from these plants. Solids from the steel industry amounted to 230 tons in 1949 which tonnage was 53 per cent of the total discharged to the boundary waters.

Solids from blast furnace flue gas wash water and mill scale, when dewatered and sintered, comprise valuable material which is suitable as a portion of the blast furnace charge. These solids settle readily but efficient recovery requires sedimentation units with provision for concentrating and dewatering of the sludge. Efficient thickeners will recover in excess of 96 per

cent of blast furnace solids and produce a 35 to 45 per cent moisture sludge. Vacuum filtration further reduces the moisture content. If the filter cake approaches 18 per cent moisture it is acceptable for sintering, otherwise it must be stock-piled and allowed to air dry.

During the past four years, clarifiers and thickeners have been installed to provide efficient recovery of solids from the blast furnace gas wash water for furnaces located in Lackawanna. Prior to 1950, a portion of these solids was recovered in short-time settling basins routinely cleaned by a clam-shell dredge. The more efficient recovery has removed an additional 115 tons of suspended solids daily from the boundary waters. In addition, positive means are now available for concentrating and dewatering the sludge. Recent expenditures totaling some $2,500,000, by the two Lackawanna blast furnace departments for solids recovery, are reported to be sound investments.

B. Pulp and Paper

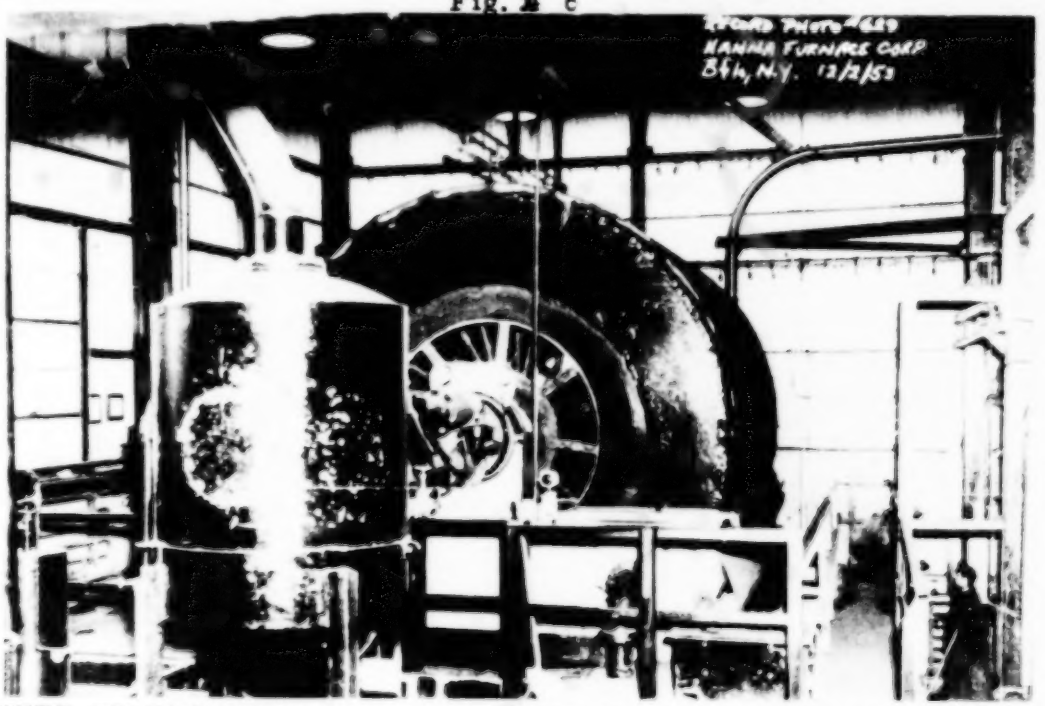
This industry discharged 88 tons suspended solids daily to the boundary waters in 1949 representing 20.3 per cent of the total. These solids losses are high because of the volume of reclaimed paper stock used as raw material by one mill. Through extensive modernization of one mill and reduced water consumption at another, paper mill solids have been reduced 5 tons per day.

C. Electrometallurgical

Carbide and ferro-alloys are produced in electric furnaces. Many of these furnaces are covered and the furnace gases with entrained dust particles are removed by wet scrubbers. The water from these scrubbers constitutes the principal liquid waste from this industry.

During the past 5 years, suspended solids from these wet scrubbers in-

CLARIFIER SYSTEM FOR REMOVAL OF SETTLEABLE SOLIDS
FROM BLAST FURNACE FLUE GAS WASH WATER
(Courtesy The Hanna Furnace Corporation)
Fig. 6



OLIVER FILTER USED IN DEWATERING SLUDGE FROM CLARIFIERS
(Courtesy The Hanna Furnace Corporation)
Fig. 7

creased from 37.6 to 81 tons daily. This 115 per cent increase was brought about by installation of additional scrubbers to reduce air pollution. Most of these wastes, 8.1 M.G.D., are now passed through a 130 ft. diameter clarifier which was placed in service late in 1949. This unit removes approximately 64 tons solids daily for an average efficiency of 97 per cent. The effluent carrying some 0.5 ton suspended solids drains to Niagara River. Sludge from the clarifier has no value and is lagooned. Wastes not yet diverted to the clarifier and containing about 16.5 tons suspended solids daily are discharged to sewers leading to the Niagara Falls sewage treatment works.

D. Electrochemical

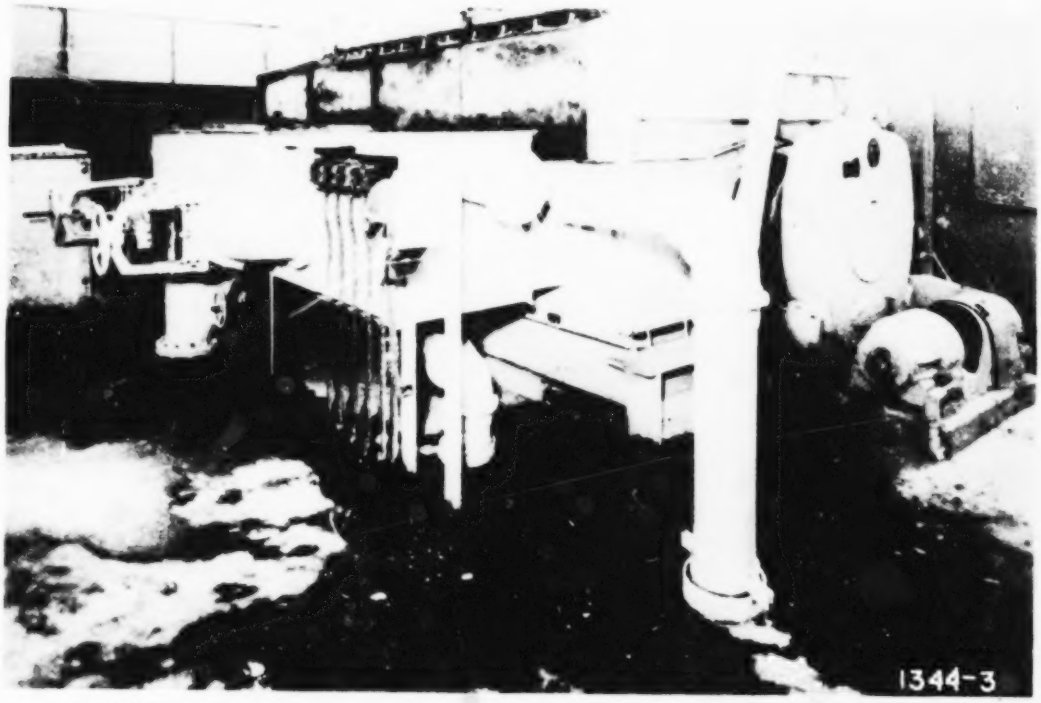
Suspended solids in the liquid wastes from four manufacturing plants of the electrochemical industry amounted to 46 tons daily in 1949 which was 10.7 per cent of the total reported for the area. One plant accounted for 88 per cent of these solids. Through development and process modification these solids, which are largely inert, have been reduced to 14 tons per day.

E. Miscellaneous

There were 8 manufacturing plants in this group discharging some 32 tons suspended solids per day in 1949 which was 7.5 per cent of the total. Three industries produced 92 per cent of these solids. These were synthetic organic chemicals and dyes, carborundum, and synthetic fiber. Some improvements have been made but their effect has been offset by increased production. It has been estimated that solids losses from these combined sources has actually increased 5 per cent.

Acids

Acid wastes were significant in the effluents from nine manufacturing



OLIVER UNITED VACUUM FILTER USED TO RECOVER
FIBER AT PULP AND PAPER MILL
(Courtesy International Paper Company)
Fig. 8

CLARIFIER FOR REMOVAL OF SETTLEABLE SOLIDS FROM
GAS SCRUBBER WATER FROM ELECTRIC FURNACES
(Courtesy Electro Metallurgical Company)
Fig. 9

plants. The primary source was spent pickle liquor from the steel industry. Other major sources included the wastes from manufacture of synthetic organic chemicals, synthetic fibers, and spent sulfuric acid used in drying chlorine gas. Free acid and hydrolyzable sulfate have been converted to calcium carbonate equivalent as shown in table 4.

The steel industry was accountable for approximately 50 per cent of the acid wastes in this area in 1949. In the meantime, total acids discharged have been reduced about 35 per cent. This has been accomplished largely by process changes, improved control, and neutralization. Some plants have both caustic and acid wastes; others neutralize with lime. Spent pickle liquor now constitutes roughly 75 per cent of the total.

Steel was pickled in both batch and continuous equipment. Spent pickle liquor from batch operations was dumped over relatively short periods. This practice results in intermittent acid concentrations in the receiving waters substantially above those indicated by the average daily discharge. Furthermore, the iron content of these acid wastes may impair the receiving water for both domestic and industrial uses.

Automatic flame scarfing has been substituted for pickling of certain steel products at one mill. This does not eliminate pickling because scarfing is not applicable to all steel products. However, generation of acetylene required by the scarfing machine produces a calcium hydroxide slurry. This basic material is then available to neutralize the spent pickle liquor from those steel products that must be acid cleaned. For this particular mill, caustic waste exceeds that required for neutralization of the free acid in the spent pickle liquor.

An acid manufacturing plant has achieved marked reduction of acid losses

TABLE 4

ACIDS DISCHARGED DAILY
TO UNITED STATES WATERS
1949

Plant	Materials Discharged		$CaCO_3$ Equivalent[1]
	Type	Lb./Day	(Lb./Day)
A[2]	H_2SO_4	6,285	6,400
	$FeSO_4$	103,000	67,700
B	H_2SO_4	3,680	3,760
C	H_2SO_4	33,600	34,300
D	H_2SO_4	650	665
E	H_2SO_4	22,700	23,200
F	H_2SO_4	23,900	24,400
G[3]	H_2SO_4	1,125	1,150
	$FeSO_4$	10,480	6,890
H	H_2SO_4	284	290
I[3]	H_2SO_4	1,730	1,770
	$FeSO_4$	16,100	10,600
	Hcl	1,690	2,310
Total			183,435

1 Computed on basis of sulfate.

2 Intermittent dumping converted to daily basis.

3 Based on acid consumption.

through physical improvements, instrumentation, and vigilant control. Improvements included replacement of obsolete and worn-out equipment, use of more acid resistant materials, and electrical facilities which minimize power failures. This is an excellent example of pollution abatement by improvements within the plant, and control.

Caustic Wastes

Large scale production of chlorine by the electrolysis of solutions of sodium chloride results in caustic wastes which impart a high pH to several industrial effluents at Niagara Falls. In addition, generation of acetylene from calcium carbide results in a slaked lime slurry waste of some significance in the same area. The former waste has been reported to raise the pH of the river water, in the immediate vicinity of discharge, sufficiently to interfere with coagulation of water taken through nearby shore intakes and treated for industrial use.

Biochemical Oxygen Demand

This determination was made on those wastes containing significant quantities of decomposable organic matter. Some of these wastes also contained such reducing substances as sulfides and ferrous compounds which exerted an immediate chemical oxygen demand. The biochemical oxygen demand data were of greatest value in studying oxygen relationships for tributaries to the boundary waters. The diluting capacity of Niagara River reduced the dissolved oxygen deficit to a negligible value.

The two largest contributors of wastes high in oxygen demand are the pulp and paper industry and plants manufacturing synthetic organic chemicals, dye intermediates and dyes. These industries are responsible for well over 60 per cent of the B.O.D. discharged to the boundary waters and tributaries. Some of these wastes are discharged to Buffalo River and others enter Niagara River at the Tonawandas and Niagara Falls. A considerable quantity of these wastes enters the Niagara River below the falls through the Edward Dean Adams Power Station tailrace and the Niagara Falls sewerage system.

Miscellaneous

Chlorine demand, taste, and odor results were of greatest value in appraising the effect of industrial effluents on public water supplies and water treatment. Erratic chlorine demand in surface water received at municipal water purification plants constitutes a real public health hazard in that some water may reach the consumers with inadequate disinfection.

The non-specific taste and odor tests are a catch-all for many substances which have not been identified or for which suitable analytical determinations have not been perfected. They are invaluable as an aid in producing a potable water and occasionally can be used to trace taste and odor producing compounds to their source.

New Parameters

Standard methods were employed in all analytical work. These results gave a reasonably satisfactory measure of the pollutional effect of these industrial wastes. Cognizance was taken of the fact that much remains to be learned about certain specific wastes as well as their combined effect on the receiving waters. It is probable that further research on the various wastes and new or modified test procedures will reveal more significant parameters of pollution in the future.

Effect on Boundary Waters

Samples were collected at strategic points in the Boundary Waters during the 1948-1949 studies with the objectives of determining their sanitary quality and insofar as possible to establish the pattern of dispersion for pollutional materials. Water, as received at municipal intakes, was also routinely analyzed during the survey and again in the spring of 1952. Because of its persistence,

phenol has been used to show the course of travel for pollutional materials.

Meteorological conditions are of extreme importance in studying pollution of and interpreting analytical results for these Boundary Waters. This was mentioned in the section presenting hydrographic information but is reemphasized here. Monthly climatological summaries for Buffalo, N.Y. (Airport) prepared by the U. S. Department of Commerce, Weather Bureau have been reviewed in an endeavor to correlate observations in the East End of Lake Erie and the upper Niagara River with wind velocities and direction, and precipitation. In examining these data, cognizance must be taken of the fact that sampling by boat was not feasible during high winds and severe storms. Attempt was made to evaluate the increase in pollution load and the greater dispersion, during and following storms, by sampling from bridges and at water purification plants.

During the 15 month period July 1, 1948 to September 30, 1949, there were 18 days when the wind attained a velocity of 40 m.p.h. or more. The maximum velocity recorded was 52 m.p.h. which occurred January 19, 1949. The wind direction was from the southwest each time the maximum velocity was recorded, with two exceptions; once the wind direction was from the west and the other time from the northwest.

Dilution

The results of subsurface float studies, conducted along the east shore of Lake Erie and reported in 1910, showed littoral currents and currents some distance from shore normally moving in a northerly direction toward Niagara River (9). These same studies indicated that lake water flowed into Buffalo Outer Harbor through the south, middle, and north entrances. This direction of flow would normally prevent wastes discharged into the Outer Harbor from mixing with the main body of lake water.

Conditions along the east shore of Lake Erie are somewhat different today than they were in 1910. The south entrance to the Outer Harbor has been altered by a 2000 foot extension of the south breakwater. The more recent dredge dump area, previously described, would be expected to impede natural flow along the lake shore toward Niagara River. Furthermore, sustained high wind would cause polluting materials, discharged along the shore, to penetrate more deeply into the lake.

Lateral mixing in the upper portion of Niagara River increases with increase in flow from Buffalo River. This effect is minimized in the high velocity section of the river paralleling Black Rock Canal. It becomes more pronounced in the river section approaching the International Railroad Bridge crossing at Squaw Island and continues into the east channel. This increase in lateral mixing can be readily detected by turbidity and color contrast with the cleaner Lake Erie water, the line of demarcation being visible for several miles. In the numerous studies that have been made by various agencies over a long period of years, there has never been any evidence or data obtained indicating that this expanded zone of pollution significantly affected the west channel.

Perhaps the most important consideration in studying the upper Niagara River is the relatively small portion of the total flow which is available for dilution. There is a strong tendency for tributary, industrial, and municipal discharges to follow and remain along the shore. This condition is highly significant in disposing of acids and toxic materials requiring dilution to render innocuous.

Lake Erie

Sampling on ranges LC, WS, LW, and IW-P was confined to September and

October 1948 and to May, June, and July 1949. It was possible to sample in the Outer Harbor as late as December and as early as April. Maximum and average phenol concentrations are shown graphically in Figure 3.

The highest phenol values along the east shore of Lake Erie occurred in the vicinity of the mouth of Smokes Creek. Ranges 1E, 2E, and 3E all showed relatively high phenol concentrations over 2000 feet from shore. Residual by-product coke wastes were a major source of phenol along the east shore and in the Outer Harbor.

Maximum phenol values observed on range WS were of particular interest. Phenol was found in only 4 out of 15 samples collected on this range but in each of these 4 the concentration was relatively high. The following information supplements that recorded in Figure 3.

Range WS

Date May 1949	Miles from U.S. Shore	Phenol ppb
11	1.4	160
11	2.4	45
17	1.4	35
17	3.4	140

Lake water temperatures during this 7 day period ranged from 8 to 12 degrees centigrade. Water depth in this part of the lake averages about 30 feet which may result in temporary thermal stratification of the warmer industrial discharges. Travel of pollution into the lake in this instance was attributed primarily to prevailing winds. These are tabulated below:

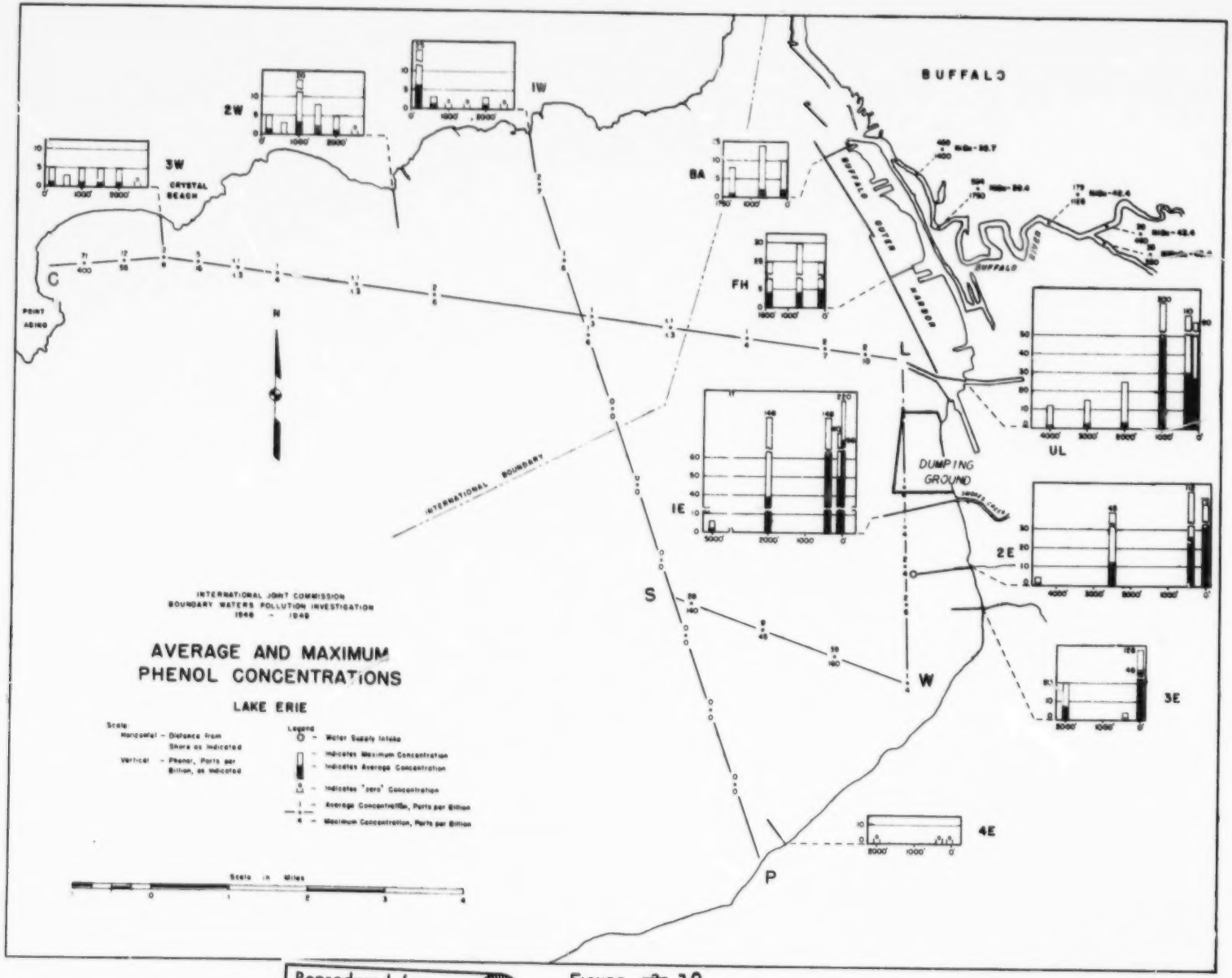


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FIGURE 10

Climatological Summary - Buffalo, N.Y. (Airport)

Date May 1949	Wind	
	Prevailing Direction	Highest Velocity M.P.H.
7	NE	25
8	SE	18
9	N	19
10	E	26
11	E	19
15	E	16

Unfortunately range WS terminated 3.4 miles from shore. Inasmuch as the phenol concentration was 140 ppb at this point, at the time of sampling, it is reasonable to suppose that phenol penetrated beyond this point in the lake.

The phenol results for range LC are likewise believed to be significant. The highest concentrations observed on this range were in the bay between Point Abino and Crystal Beach, Ontario. Pertinent supplemental data for these maximum values are tabulated below:

Date	Range LC	
	Miles from Outer Harbor South Pier Light	Phenol ppb
Sept. 15, 1948	9.0	16
May 9, 1949	10.0	55
May 9, 1949	10.5	400

During the first 7 days of September 1948, the prevailing winds were from the southeast and south. Wind velocities were moderate for two weeks preceding the September 15 sampling. A total of 83 samples was collected on range LC and 29 (35 per cent) showed phenol. Excluding the three high values, phenol concen-

tions ranged between 3 and 10 ppb.

The high phenol concentrations in the Crystal Beach area cannot be satisfactorily explained from available data. It is entirely possible that further investigations may reveal contributing sources of phenol not now recognized. However, the analytical data demonstrated that phenol existed along both the United States and Canadian shores and permeated the east end of Lake Erie during the period of the I. J. C. field study. Furthermore, under certain meteorological conditions, there was positive evidence of rapid dispersion and deep penetration of significant phenol concentrations into the lake. These observations serve to explain the occasional presence of phenol throughout the full width of the upper Niagara River above Grand Island and in the west channel. The persistence of phenol in clean water lends credence to this hypothesis.

Upper Niagara River

Routine sampling of the Upper Niagara River was initiated in August 1948 and continued into July 1949. It was necessary to suspend sampling by boat during January, February, and March but river sampling from bridges was intensified during the winter months. The International Railroad Bridge at Squaw Island and the two Grand Island Bridges across the east channel were used. Average and maximum phenol concentrations are plotted as barographs in Figure 4.

A mileage index system was used to identify river sampling ranges. This system involved the use of the letter Ni followed by a number which represented the distance in river miles from the mouth of Niagara River. The zero mileage point was taken one mile from the mouth of the river in Lake Ontario at a bell buoy (B-1) established by the U. S. Coast Guard. Distances from

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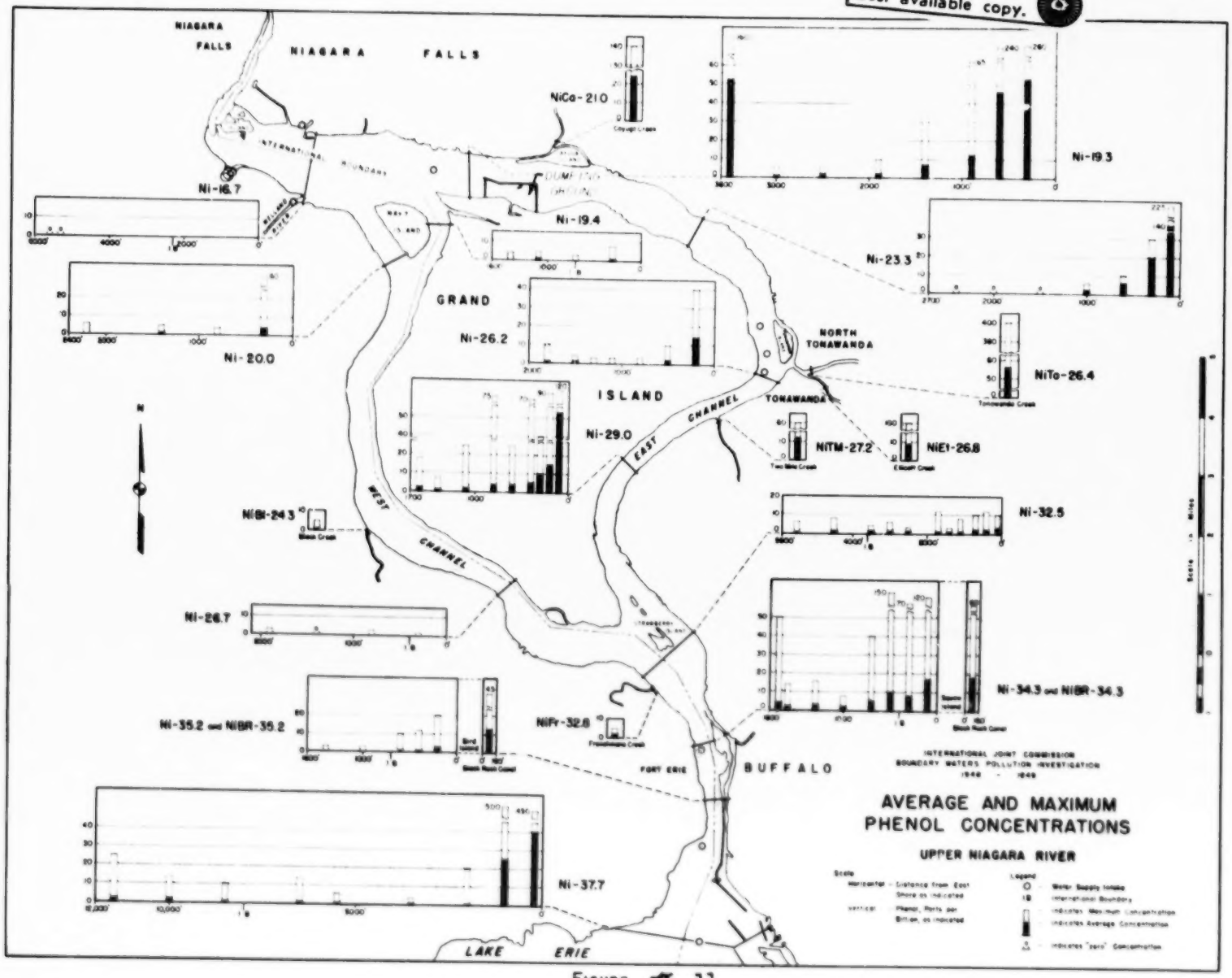

FIGURE 11

this zero point were measured via the East Channel around Grand Island.

Range Ni-37.7 was located just below confluence of Buffalo and Niagara Rivers and Buffalo Harbor and extended to the Canadian shore in line with the city of Buffalo water intake. The maximum concentrations occurred April 7, 1949 following moderate rainfall the day before. Considering phenol results for Buffalo River, which were as high as 3600 ppb at the mouth December 22, 1948, it is probable that these values do not represent the most adverse conditions. The phenol which showed up at each sampling point on this range confirms phenol that was found dispersed through the east end of Lake Erie.

Figure 4 is especially interesting in that it illustrates the pollution pattern for that section of the boundary waters receiving the bulk of the wastes. The east end of Range Ni-35.2 was at the Ferry Dock immediately above the Buffalo Sewage Treatment Works. Sampling on this range was complicated by the high stream velocities. The phenol for this cross-section illustrates clearly how narrow the band of pollution normally is in this upper reach of the stream. The sampling point 200 feet from Bird Island shore was usually beyond the zone of pollution as indicated by the fact that 10 out of 21 samples showed zero phenol and 5 others had only a trace. The maximum value of 20 ppb occurred September 21, 1948. Rainfall on September 19, 1948 amounted to 2.09 inches and on September 20 the records showed 0.86 inch. The sampling point 400 feet from shore showed zero phenol on September 21.

Range Ni-34.3 was the International Railroad Bridge at Squaw Island. A total of 262 samples were collected on this range during the period September 2, 1948 to July 4, 1949. Sampling during adverse weather and following storms revealed increased lateral mixing. The 40 ppb phenol 700 feet from Squaw Island shore indicates that under certain conditions, the pollution zone may

cover 40 per cent of the width of the river at this point. The results for this range probably show the effect of the purging of Buffalo River as well as any river data obtained. However, extenuating circumstances occasionally prevented sampling at the most opportune time and these data do not necessarily show the heaviest pollution.

The low phenol results for range Ni-32.5, at the head of Strawberry Island, reflect both dilution and fair weather sampling. The maximum values were obtained September 20, 1948. This followed a 2.09 inch rain on September 19th. This was preceded by another storm period September 7 to 9 when a 2.57 inch rainfall was recorded. The earlier runoff would have a cleansing effect on tributary streams thereby minimizing pollution from this source at the time of the September 20 sampling.

The South Grand Island bridge was range Ni-29.0. A by-product coke plant that does not dephenolize ammoniacal liquor was located approximately 1 mile upstream. This new phenol source undoubtedly accounted for the high concentrations out 400 feet from shore. The maximum phenol of 75 ppb at a distance of 800 feet from the east shore, occurring March 10, 1949, would appear to originate farther upstream.

There were other sources of phenol in the Tonawandas which accounted for high phenol found in the east portion of the river on ranges below. There was no explanation for the 1600 ppb phenol found 100 feet from the south shore June 3, 1949 at the North Grand Island Bridge, Range Ni-19.3.

Lower Niagara River

Sampling in the lower river was conducted from three bridges and by boat on three ranges downstream from Lewiston. The location of the ranges and per-

tinent phenol data are shown in Figure 5. Complete mixing probably does not occur above the Whirlpool Rapids. These results show relatively high phenol concentrations on several occasions throughout the full length of the lower river.

Lake Ontario

Average and maximum phenol results for Lake Ontario, in the vicinity of the outlet of Niagara River, are depicted in Figure 6. Diffusion of phenol progresses from Point "O" along the fan-lake ranges diluting out in approximately 10 miles travel. A maximum result of 85 ppb was reported on range ON three miles from Point "O." With the exception of 5 other results in the order of 12 to 25 ppb, all the maximum values were less than 8 ppb and over half of the maximum values were less than 3 ppb.

Municipal Water Supplies

There are six public water supplies on the United States side taken from the Upper Niagara River and the East End of Lake Erie. Routine sampling and analysis of the raw waters at these purification plants were integrated with river and industrial effluent studies. The operating records of the larger water treatment plants were also reviewed. These studies showed the local conditions at each water plant as well as the progressive changes in water quality along the Niagara River.

Intakes for these water plants are shown on Figures 3, 4, and 5. Since the 1949 I.J.C. studies, the intake for Niagara Falls Filter Plant No. 1 has been extended from the east channel of Niagara River to the west (emerald) channel. This new intake was placed in service late in 1951. Niagara Falls Filter Plant No. 2 has recently been taken out of service thus eliminating

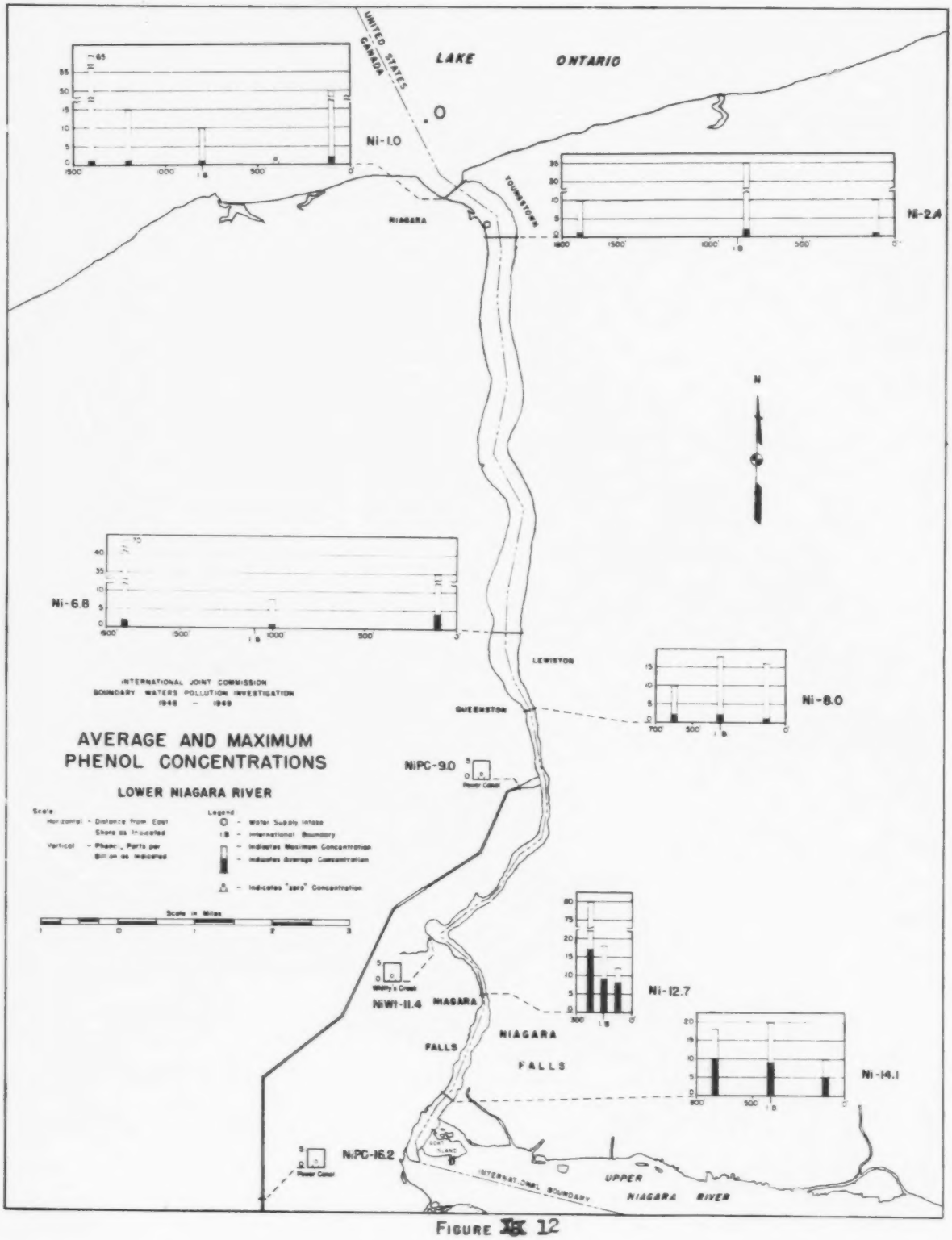
UNITED STATES
CANADA
LAKE ONTARIO
Ni-1.0
NIAGARA
YOUNGSTOWN
Ni-2.4
N
Ni-6.8
LEWISTON
QUEENSTON
Ni-8.0
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1948 - 1949
AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS
LOWER NIAGARA RIVER
NiPC-9.0
Power Canal
Scale
Horizontal - Distance from East Shore as Indicated
Vertical - Phenol, Parts per Billion as Indicated
Legend
- Water Supply Intake
I.B - International Boundary
- Indicates Maximum Concentration
- Indicates Average Concentration
- Indicates "zero" Concentration
Scale in Miles
Whirlpool
NiWI-11.4
NIAGARA
FALLS
Ni-12.7
NIAGARA
FALLS
Ni-14.1
NiPC-16.2
Power Canal
GOAT
ISLAND
INTERNATIONAL BOUNDARY
UPPER
NIAGARA RIVER

FIGURE 12

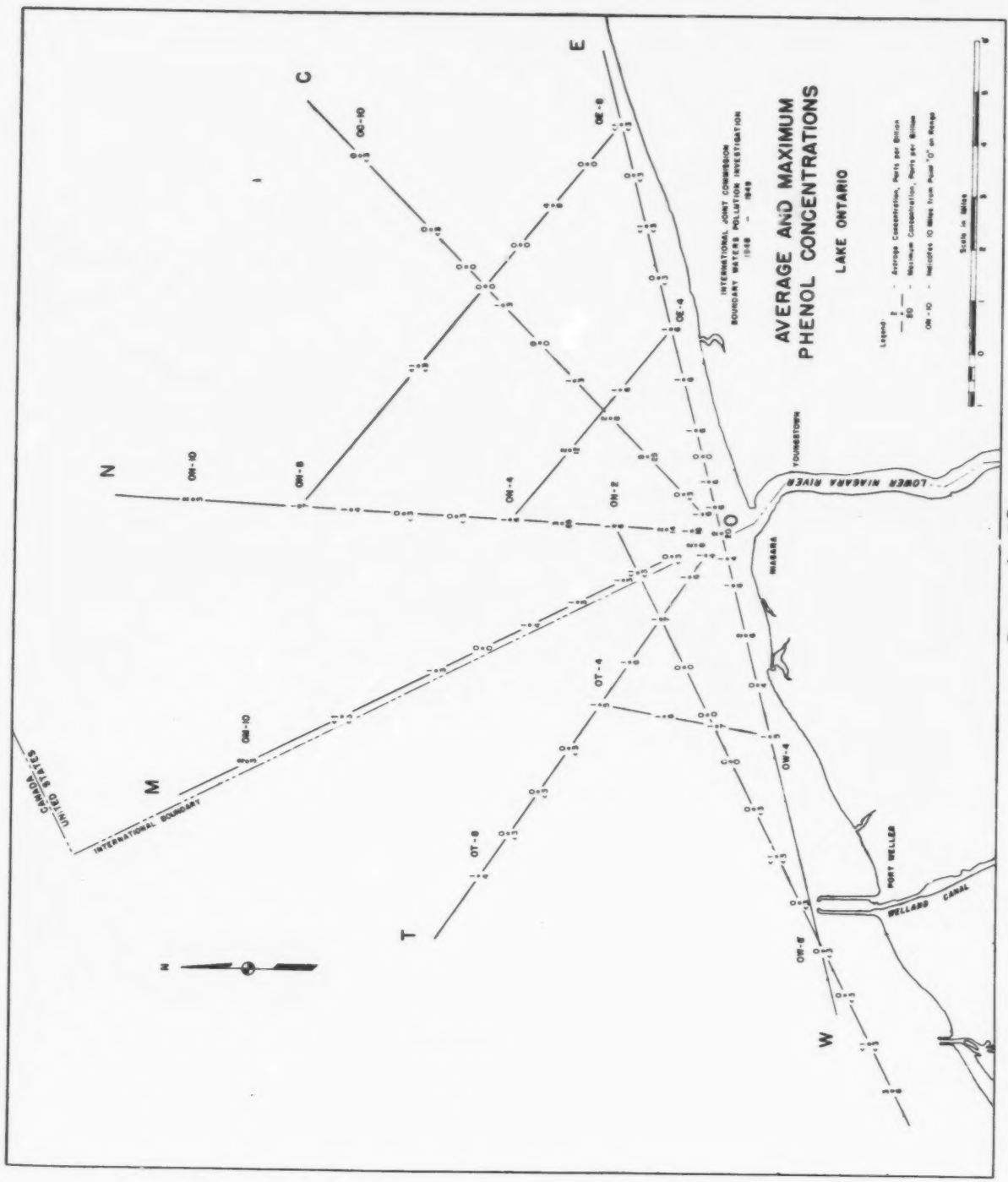
AVERAGE AND MAXIMUM
PHENOL CONCENTRATIONS
LAKE ONTARIO
INTERNATIONAL JOINT COMMISSION
BOUNDARY WATERS POLLUTION INVESTIGATION
1950 - 1949
Legend:
Average Concentration, Parts per Billion
Maximum Concentration, Parts per Billion
Indicates 10 Miles from Point "O" on Range
Scale in Miles
INTERNATIONAL BOUNDARY
UNITED STATES
CANADA
LOWER NIAGARA RIVER
YOUNGSTOWN
NIAGARA
PORT WELLER
WELLAND CANAL
N
M
C
I
E
T
O
W
ON-10
ON-8
ON-6
ON-4
ON-2
OM-10
OT-8
OT-4
OE-8
OE-4
OW-4
OW-8

FIGURE 13

the only shore intake.

The three remaining municipal intakes located in the east channel, in the Tonawanda area, are in a precarious position with respect to the normal pollution zone. The intake for Erie County Water Authority filter plant in Lake Erie is likewise within a mile of shore pollution and the dredge dump. During and following storms, these pollution zones widen and the intakes are thus subjected to sporadic "slugs" of heavy pollution. The town of Niagara, Ontario water supply, taken from the Lower Niagara River near its mouth, is markedly affected by phenol pollution.

Phenol concentrations as high as 80 ppb were observed in the city of Tonawanda raw water in 1949. Concentrations of this order frequently occurred at the Niagara Falls Filter Plant No. 2 (shore intake) when this plant was being operated. Operation of the Erie County Water Authority plant is seriously affected by intermittent high concentrationsof both phenol and iron.

The intake for the city of Buffalo is located at the Niagara River inlet near the International Boundary where the raw water is not usually affected by sewage or industrial waste pollution. Plant records for 1949 indicated that the quality of raw water taken from the Buffalo City intake met the U. S. Public Health Service bacteriological requirements for a treated water. However, this plant also receives an occasional "slug" of phenol. Routine sampling picked up phenol concentrations of 45 ppb on March 29 and 25 ppb April 26, 1949. These incidents both followed sustained high (35 to 40 M.P.H.) southwest winds.

The wide and rather rapid changes in the character and intensity of polluting substances in the raw water have adversely influenced treatment and purification. A sudden increase in pollution of the raw water results in a simi-

larly sudden increase of the chlorine required for disinfection. The erratic chlorine demands experienced at these water purification plants are a continual hazard to public health. For these reasons, the New York State Department of Health has recommended that new municipal intakes in the Upper Niagara River be located in the west channel.

In addition to disinfection, taste and odor control has been a major problem in the treatment of these waters for domestic use during the past 25 years. Little success was realized in this control until the introduction in 1943 of chlorine dioxide treatment. Chlorine dioxide is now used at each of the United States water plants, with the exception of Buffalo, at considerable additional expense. While this has improved the quality of the treated water under most conditions, occasional complaints are still received.

Industrial Water Treatment

Phenol has been reported to be a problem where a high quality process water is required. This is particularly true in manufacture of products which come in contact with food. Caustic wastes have raised the pH of the receiving waters sufficiently to interfere with coagulation of water taken from nearby shore intakes.

Fish and Wildfowl

Some 20 fish kills have been reported in the Buffalo-Tonawanda-Niagara Falls area during the past 17 years. Three of these kills occurred during November and December 1937 in the Buffalo Harbor area and were reported by the Buffalo Sewer Authority. The remaining fish kills have occurred since 1943, the last major destruction of fish being during the third week of March 1953. Most of the fish kills have been investigated and reported by the New York State Depart-

ment of Conservation.

While the relative severity of each of the kills has not been estimated, the causative toxic agent for most of them has been determined. Cyanides were implicated as causing nine of the kills with phenols a contributing factor in two cases. A lethal dose of chlorine presumably was the cause of two of the kills, while high concentrations of copper and iron salts possibly caused four others. The toxic materials causing the remaining kills, which include the three in 1937, could not be isolated. A large portion of the fish destroyed have been minnows, particularly the "lake shiner." However, pike, bass, sunfish, and crayfish have been killed in lesser numbers. The sources of the polluting substances causing these kills have been identified in several instances.

Destruction of fish is an obvious manifestation of damage from pollutional materials. There are other more subtle effects on both the fish and the food on which they must feed. Settleable solids tend to blanket the bottom of these boundary waters. Such materials as tar and oil coated solids are toxic to aquatic organisms. The detrimental effect of numerous soluble materials though recognized is very difficult to accurately express. Cognizance has been taken of natural conditions which may influence fish life.

Because the Niagara River is an important gathering point for migratory wildfowl, any pollution causing damage to the fowl is of economic importance. Oil coating of protecting plumages not only causes over-exposure in icy waters but also renders the birds helpless. Occasions have been reported of large numbers of birds being swept over the falls as a direct result of oil pollution.

Navigation

A considerable portion of the suspended solids previously described settle

readily. Those solids discharged directly to the boundary waters and navigable tributaries, together with silt from natural erosion, require a routine dredging program. In some instances, the source of the solids of industrial origin can be identified.

Recreation

The waters in the Buffalo area and in the Lower Niagara River below Lewiston and Queenston are widely used for pleasure boating. Some 1800 small power boats use the waters in the eastern end of Lake Erie and the Upper Niagara River. Serious damage to boat hulls from oil was reported by the owner and operator of one marine supplies establishment.

Pollution has interfered with development of areas suitable for bathing. Swimming along the waterfront of residential property is practiced with little regard for the health hazards. The State operated bathing beach at the south end of Grand Island is satisfactory but remotely located with respect to the center of population.

Progress in Pollution Control

Reduction in quantities of pollutional materials discharged to the boundary waters during the past five years is shown by comparison in tables 2 and 3. The methods of accomplishing these reductions have been briefly described in the sections dealing with the particular wastes. The greatest reductions have been in cyanides and suspended solids. The slight increase in oil waste is temporary as explained in that section. Real progress has been made in providing facilities to prevent oil losses. In numerous instances, modernization and process changes have reduced wastes. In others, recovery has proven a profitable venture. During this same period, industry expanded and production was

generally on a higher level in 1953 than it was in 1949.

New facilities are currently being installed at a number of plants which will further reduce waste losses. Many of the industries are solving their waste problems simultaneously with the design of new equipment. Others are actively engaged in research in an effort to develop suitable control and treatment processes.

Continuing Program

There is evidence of a definite trend toward monitoring of industrial effluents with the view of establishing a continuous and permanent record. This is an essential requirement in the development of an equitable pollution abatement program for a highly industrialized area such as the Niagara Frontier. The substantial progress that has been achieved by industry and the planning for the future are consistent with the doctrine of "best usage of waters in the public interest" promulgated by the New York State Water Pollution Control Board.

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